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DATA COMMUNICATIONS SYSTEM AND METHOD FOR COMMUNICATION BETWEEN INFRARED DEVICES

by

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CROSS-REFERENCE TO RELATED APPLICATIONS

This application claims the benefit of U. S. Provisional Patent Application Serial No. 60/267,441 entitled, "Remotely Managed Automatic Dispensing Apparatus and Method", filed on February 8, 2001, and U. S. Provisional Patent Application Serial No. 60/240,898 entitled, "Remotely Managed Automatic Dispensing Apparatus and Method", filed on October 24, 2000, both of which are hereby incorporated by reference herein.

BACKGROUND OF INVENTION

1. **Field of the Invention**

The present invention relates generally to the field a data communications between infrared (IR) devices, and more particularly to data communication between a handheld computer having an optical interface port that transmits and receives signals with an optical interface port of an automatically activated fluid dispensing device.

2. **Technical Background**

Standard IR devices communicate in accordance with the Infrared Data Association Serial Infrared Physical Layer Specification (hereinafter referred to as the Serial Infrared Specification) promulgated by the Infrared Data Association (IrDA). The IrDA is a standard body that publishes specifications containing the criteria by which IR device manufacturers must comply in order to claim IrDA compliance. The Infrared Data Association Serial Infrared Specification is incorporated herein by reference.

The physical layer specification governs point-to-point communication between electronic devices, such as computers and peripherals, using directed half-duplex, serial infrared communication links through free space. The physical elements, including the

optical links and active input and output interfaces, are described in the physical layer specification. In order for a device to be IrDA compliant, the device must be designed to meet the specifications as indicated in the physical layer specification.

In particular, the IrDA Physical Layer Specification places constraints on the communication procedure when a device attempts to establish an optical link with a second device. The IrDA Physical Layer Specification sets forth requirements that govern the behavior of a device having a transmitter/detector pair when establishing an optical link. Compliance with the IrDA Physical Layer Specification requires that the device sample its detection range. An IrDA compliant device will not transmit a pulse to another device to request a link until it detects 500 msecs of "media quiet." "Media quiet" means that there is no IR activity detected during the 500 msecs duration.

Once an optical link is established between two devices, IrDA compliance requires that a serial interaction pulse (SIP) be emitted every 500 msecs to quiet other potentially interfering systems. In other words, the 500 msecs "media quiet" requirement will ensure that the potentially interfering device detects an SIP every 500 msecs thereby precluding the device from attempting to establish a connection.

The SIP is required by the Physical Layer Specification to quiet slower systems that might interfere with the optical link established between the transmitter and the receiver. An SIP is a 1.6 microsecond pulse followed by a 7.1 microsecond off time of the transmitter. The SIP simulates a start pulse that requires a potentially interfering system to listen for at least 500 milliseconds prior to establishing an optical link.

In accordance with the Physical Layer Specification, optical sensors are commonly employed with IR transmitters which, together with processing electronics, are used to detect an object in the range of the IR transmitter. An IR pulse is emitted, and if it strikes an object in its range, the pulse is reflected. An IR sensor is placed strategically in order to detect the reflected pulse.

The dichotomous emitter/sensor technology is employed in various applications including automatically activated fluid dispensing devices. Such dispensing systems, such as hand activated water faucets, generally include an infrared emitter that emits a timed pulse. When an object, such as a user's hands, is within the emitter's range, it reflects the pulsed IR beam, and the optical sensor detects the reflected light from the user's hands. In such a system, an IrDA compliant device emits a pulse every 250 milliseconds.

Automatically activated fluid dispensing devices have a myriad of operating pitfalls. For example, devices such as IR controlled faucets require extensive manual servicing and maintenance. Inherently, in an environment such as an office building having numerous floors and numerous faucets in each of the restrooms on each of the floors, servicing and maintenance of the IR controlled devices is often a burdensome and time consuming task. Many simple tasks associated with the maintenance of the faucets, including battery replacement, IR range monitoring, and solenoid malfunction detection, are typically performed per faucet per restroom per floor in an office building. This type of monitoring of malfunctioning units dictates manual interaction with each unit for diagnostics, maintenance, calibration, and servicing.

SUMMARY OF THE INVENTION

Generally, the present invention provides a system and method for establishing optical links between devices that include transmitter/detector pairs.

The present invention is a system designed to facilitate communication between IR devices. A first device includes an initiating transmitter and an initiating detector. A second device includes a receiving transmitter and a receiving detector, and the receiving transmitter is configured to transmit pulses. The initiating control logic is configured to transmit an Attention Signal from the initiating transmitter where that transmitter is

within detection range of the receiving detector. The receiving control logic is configured to discontinue the pulse transmitted by the receiving transmitter upon detection of the Attention Signal transmitted by the initiating transmitter.

The present invention is further a method for facilitating communication between IR devices. The method is broadly conceptualized by the following steps: emitting an Attention Signal from an initiating transmitter; detecting the Attention Signal by a receiving detector that is coupled to a receiving transmitter that is actively transmitting pulses; discontinuing the active transmission of pulses by the receiving transmitter; establishing an optical link between the initiating transmitter and initiating detector and the receiving transmitter and receiving detector.

The forgoing general description and the following detailed description are merely exemplary of the invention. Each is provided to show an overview or framework for understanding the nature and character of the invention as it is claimed. The accompanying drawings are included to provide further understanding of the invention and are incorporated and constitute part of the specifications. The drawings illustrate various embodiments of the invention and together with the description serve to explain the principles and operation of the invention.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a block diagram illustrating a data communication system in accordance with a preferred embodiment of the present invention.

FIG. 2 is a flowchart illustrating the event loop of the control logic **120** in **FIG. 1** of Remote management node of the present invention.

FIG. 3 is a flowchart illustrating the communication function called by the event loop **114** from the communication function call **122** illustrated in **FIG. 2.**

FIG. 4 is a detailed flowchart of the send status command called by the communication module **132** from the send status **146** in **FIG. 3**.

FIG. 5A-5D is a flowchart illustrating the general functionality of the overall firmware structure of the fluid dispensing device that is integral part of a preferred embodiment of the system and method of the present invention.

FIG. 6A-6B is a flowchart illustrating the Interrupt Driven IR and Battery Thread of the firmware of the fluid dispensing device that is integral part of a preferred embodiment of the system and method of the present invention.

FIG. 7A-7J Flowcharts illustrating the IR and Battery Detection Thread of the firmware of the fluid dispensing device that is integral part of a preferred embodiment of the system and method of the present invention.

FIG. 8A-8F Flowcharts illustrating the Motion Detection Thread of the firmware of the fluid dispensing device that is integral part of a preferred embodiment of the system and method of the present invention.

FIG. 9A-9D is a flowchart illustrating the Motion Detection Thread of the firmware of the fluid dispensing device that is integral part of a preferred embodiment of the system and method of the present invention.

FIG. 10 is a block diagram illustrating the data unit descriptions of a Broadcast signal.

FIG. 11 is a block diagram illustrating the data unit descriptions of an Attention signal.

FIG. 12 is a block diagram illustrating the data unit descriptions of a Connected

Mode request signal.

FIG. 13 is a block diagram illustrating the data unit descriptions of a Status signal.

FIG. 14 is a block diagram illustrating the data unit descriptions of a Set signal.

FIG. 15 is a block diagram illustrating the data unit descriptions of a Program signal.

FIG. 16 is a block diagram illustrating the data unit descriptions of a End signal.

FIG. 17 is a graphical depiction of the graphical user interface of a handheld computer illustrating five (5) user options available, including three options that require an optical link with the fluid dispensing device of the present invention, "Get Faucet Data", "Adjust Faucet", and "Scan For Problems".

FIG. 18 is a graphical depiction of the graphical user interface of a handheld computer illustrating the "Get Faucet Data" option form that allows a user to retrieve current fluid dispensing device parameters.

FIG. 19 is a graphical depiction of the graphical user interface of a handheld computer illustrating the "Adjust Faucet" option form that allows a user to edit current fluid dispensing device parameters.

FIG. 20 is a graphical depiction of the graphical user interface of a handheld computer illustrating the "Scan For Problems" option form that allows a user to retrieve Broadcast signals as diagrammed in FIG. 10 from a set of fluid dispensing device

FIG. 21A-B is a flowchart illustrating the overall software flow of the firmware structure of the fluid dispensing device as shown in **FIG. 5A-5D**.

FIG. 22 is a flowchart illustrating the Broadcast functionality of the fluid dispensing device and the data unit that is depicted in **FIG. 10**.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

Reference is now made in detail to a present preferred embodiment of the present invention, examples of which are illustrated in the accompanying drawings. Wherever possible, the same reference numerals will be used throughout the drawing figures to refer to the same or like parts. An exemplary embodiment of the data communication system and method of the present invention is illustrated in the block diagram of **FIG. 1** and is designated generally throughout by reference numeral **98**.

In accordance with the invention, the hardware elements of the data communication system of the present invention include Remote Management Node **100** and Managed Node **102**. Remote Management Node **100** includes generally an optical interface port **104**, a processing element **110**, and a memory element **112**. Managed Node **102** includes generally an optical interface port **106** and an electronics module **114**. The optical interface port **106** of Managed Node **102** includes an emitter **118** and a detector **116**. The emitter **118** has a pulse range **109** wherein an object within the arc will reflect a pulse that will be detected by detector **116**. Communication between Remote Management Node **100** and fluid dispensing device node **102** is accomplished by an optical link **108** in free space between the optical interface port **104** and **106**.

The Memory Element **112** of Remote Management Node **100** houses the remote management control logic **120**. Processing element **110** manipulates the optical interface port **104**.

Managed Node **102** further includes Mechanical Elements **123**, known to those skilled in the art, necessary for controlling water flow of a fluid-dispensing device **102**.

The electronics **114** include further a Managed Node Control Logic **122** that controls functionality of the optical port **106** and the manipulation of Mechanical Elements **123**.

The emitter **118** of Managed Node **102** periodically emits a pulse, such as every 250 milliseconds, for example. The pulse emission creates an optical signal in free space. In order for the optical interface port **104** of Remote Management Node **100** to establish an optical link with the optical interface port **106** of Managed Node **102** Remote Management Node Control Logic **120** resides in a memory component **112** of Remote Management Node **100**. The Remote Management Node Control Logic **120** can be implemented in software, hardware, or combination thereof.

The Remote Management Node Control Logic **120** causes the emitter **105** to emit an Attention signal from the optical interface port **104**. The Remote Management Node Control Logic **120** is managed and manipulated by the microprocessor **110**. The attention signal that is emitted from the optical interface port **104** is transmitted regardless of its detection of "media quiet" environment. In other words, the Attention Signal is emitted despite the 250-millisecond infrared pulse of the emitter **118** of Managed Node **102**.

As previously described, the electronics **114** in cooperation with the Managed Node Control Logic **122** cause the periodic emission of an infrared pulse from the emitter **118.** In this regard, the emitter **118** causes such an emission every 250 milliseconds. Prior to emission of the infrared pulse, the detector **116** attempts to detect an attention signal that is emitted from the optical interface port **104** of Remote Management Node **100**. If an attention signal is not detected, the emitter **118** is allowed to operate normally, emitting an infrared pulse every 250 milliseconds. If, on the other hand, an attention signal is detected, normal operation of the emitter is discontinued and an optical link **108** is established between the optical interface port **104** and the optical interface port **106**. If the attention signal is not detected, then normal operation of the emitter **118** continues.

In the preferred embodiment Remote Management Node **100** is a handheld or portable device or computer, and Managed Node **102** is a fluid dispensing device.

During normal operations, the automatically activated fluid dispensing device emits an infrared pulse from emitter **118** every 250 milliseconds. If an object is within pulse range of the emitted signal, the signal is reflected and the detector **116** detects the reflected signal. If the detector **116** detects the reflected signal, then the electronics **114** will activate a solenoid **101** causing fluid to be dispensed from the device.

A handheld computer **100** allows a remote user to interrupt the normal operation of the Managed Node **102**. In order for the handheld computer to communicate with the Managed Node **102**, an optical link **108** is established between the optical interface port **104** of the handheld computer **100** and the optical interface port **106** of the fluid dispensing device **102**. The optical link allows a maintenance user to perform various maintenance function remotely, including retrieving device-specific data stored by the electronics **114** of the fluid dispensing device **102**, adjusting electronics parameters, or reprogramming the software that controls the fluid dispensing device.

HANDHELD COMPUTER SOFTWARE

The Remote Management Node Control Logic **120** (**FIG. 1**) on the handheld computer **100** (**FIG. 1**) initiates an optical link **108** (**FIG. 1**) between the optical interface ports **104** and **106** in accordance with a user's instruction. A description of the Remote Management Node Control Logic on the handheld computer **100** is now described in more detail with reference to **FIG. 2, FIG. 3,** and **FIG. 4**. The flow charts are merely exemplary and other methodologies may be employed to implement the present invention.

The Remote Management Node Control Logic **120** (**FIG. 1**) generally controls a user interface, input and output to the user interface, and input and output through optical interface port **104** (communication between optical interface ports). **FIG. 2** is a high level illustration of the Remote Management Node Control Logic **120** (**FIG. 1**). Event loop **124** of the Remote Management Node Control Logic **120** (**FIG. 1**) executes on the

handheld computer **100**. In essence, the event loop monitors input and output activity. This monitoring step of the remote management control logic is represented in the event loop **124** by the processing symbol **128**. When an event occurs, the event loop **124** then determines whether the event is one that requires the establishment of an optical link between the handheld computer and the fluid dispensing device in decision symbol **130**. Events that require an optical link include retrieving data from the fluid dispensing device **102** providing a user data accessibility, reprogramming the Managed Node Control Logic **122** on the fluid dispensing device **102 (FIG. 1)**, or reconfiguring electronics parameters on the fluid dispensing device **102 (FIG. 1)**. The decision symbol **130** represents that part in the control logic where the input retrieved from step **128** is analyzed to determine whether the event requires the establishment of an optical link.

If an optical link is not required to perform the function requested in step **128** by the user, then the event loop **121** of remote management control logic **120** determines whether the user has requested that a group of fluid dispensing devices be scanned as indicated by decision symbol **134**. The scanning of various fluid dispensing devices is discussed further herein. If the event does not require the scanning of a set of fluid dispensing devices, then the event requested by the user is processed in step **138** by the palm event handlers that do not require the establishment of an optical link between the handheld computer **100 (FIG. 1)** and the fluid dispensing device **102 (FIG. 1)**.

If at the decision symbol **130** it is determined that the requested event requires an optical link, then the communication function is called in processing symbol **132**. The communication function is illustrated in **FIG. 3** and is designated generally throughout as reference numeral **142**. The communication function is entered at step **132** in **FIG. 2** at the input/output symbol **144** in **FIG. 3**.

The communication function **142** first ascertains the status of the optical interface port **104 (FIG. 1)** represented by the decision symbol **146** in the communication function **142**. If the port is in a closed state, then the serial port is initialized indicated by the processing step **148**. Once the port is initialized, the IR-State variable is set to OPEN in the processing symbol **150**. Once the port is initialized and the IR-State is set to OPEN, the handheld computer is now configured for communication with the optical interface port **106 (FIG. 1)** of fluid dispensing device **102 (FIG. 1)**.

The communication function **142** provides six functional capabilities. Each separate function is indicated as a different indicator in the gCommand variable. The next step **152** is represented by a switch symbol serving as a director to the appropriate function as indicated by the gCommand variable. This variable represents the event requested by the user. The six functions available are represented by the processing symbols and include Scanning **154**, Send Status **156**, Set **158**, End **160**, Program **162**, and Idle **164**.

If the user chooses to retrieve from the faucet all information about the fluid dispensing device, then at processing symbol **156** the Send Status function **178** in **FIG. 4** is called. **FIG. 4** illustrates in detail the control logic of the Send Status command function **178**. The Send Status function **178** initially determines if the fluid dispensing device is in a connected mode. This step is represented by the decision symbol **180**. The connected mode is present when an optical link **108 (FIG. 1)** is established. If the connected mode has not been established, then the remote management control logic initiates an optical signal that is emitted from the optical interface port **104 (FIG. 1)**. This step is represented by the processing symbol **182**. The signal is an Attention Signal and is referred to throughout as such. **FIG. 21** illustrates the logic flow initiated on the fluid-dispensing device when the handheld device attempts to initiate connected mode. **FIG. 21** will be described further herein.

If the fluid dispensing device is in connected mode, the Send Status command is sent as represented by the processing symbol **184**. The Send Status command requests from the fluid dispensing device a set of data describing various parameters of the device. The set of data includes parameters about the fluid dispensing device including information relating to power, settings, and usage. Power information relating to the fluid dispensing device includes unloaded volts, loaded volts, time in use, and replace battery date. The settings information includes the current operating mode, the range setting, the range offset, delayed settings, and virtual settings. The usage information consists of the number of uses, uses per day, and hours of operation. Other miscellaneous information can include current errors, past errors, software version, PCB number, and engineering change level.

Once the request for the status is sent in processing step **184**, the Send Status function **178** determines whether the command was received. This step is indicated in the software function **178** by the decision symbol **186**. If the request for status information was successful, a flag is set in the processing step **188** and the data is received by the handheld computer as indicated by the processing symbol **190**. The optical link is then terminated when the handheld computer send the End command in step **192**. The gCommand variable is set to idle in the processing step **194**, an alarm is sounded in processing step **196** to indicate to the user successful receipt, and the Send Status function exits in processing step **200**.

If the Status command is not received by the fluid dispensing device, the Send Status function **178** exits in processing symbol **200**.

When the Send Status command module **178** exits, control is returned to the Communications function **142**. In **FIG. 3**, the Communications function **142** then queries the status of the IR serial port in decision step **166**. If the IR-State is OPEN the receive buffer is flushed in processing step **168**, and the gCommand variable is queried. If the command variable is Idle, then the serial port is closed in processing step **172** and the IR-State variable is set CLOSED. The Communications function exits in processing step **176** returning control of the processing to the event loop **124 (FIG. 2)**.

With reference to **FIG. 2**, the Event Loop **124** then queries the gCommand variable to determine if scanning is taking place in decision step **134**. If scanning is taking place then the "time out" timer is reset in processing step **136**. If the handheld computer is not scanning a group of fluid dispensing devices, then the event request is handled by functions that do not require the optical communication link **108** in processing step **138**. The event loop then exits in processing step **140**.

FLUID DISPENSING DEVICE FIRMWARE

With reference to **FIG. 1**, the Managed Node Control Logic **122** of the fluid dispensing device **102** is now discussed with reference to **FIGS. 21A-B, 5A-5D, 6A-6B,** and **7A-7J**. **FIG. 21** illustrates the communication of the connected mode.

With reference to **FIG. 21A,** the logic flow of the fluid dispensing device response to a request for Connected Mode from a handheld device is shown and is generally referred to throughout as reference numeral **840**. The fluid-dispensing device response to a request for connected mode is initiated by an IR signal from the handheld device as shown by the signal transmission block **842**. This initiating signal is the Attention Signal as discussed in the introduction. During a pulse cycle, which is discussed further herein and is described in **FIG. 5**, the detector **116 (FIG. 1)** samples its detection range to determine whether an initiating transmission was sent from the emitter **105 (FIG. 1)** in a process illustrated by independent process symbol **844**. This process

samples its detection range for the Attention Signal prior to initiating a detection pulse for object reflection.

The format in which the signal is sent indicates that the signal detected is an Attention Signal, and those skilled in the art will recognize various ways that the Attention Signal can be formatted to accomplish this indication. In a preferred embodiment the Attention signal includes a stream of 'FF' characters followed by a linefeed. Also, the duration of the signal is greater than the length of the pulse cycle.

Decision symbol **848** illustrates the query that determines whether the sample received by the detector was an Attention signal (i.e. contained 'FF' characters followed by a linefeed. If the signal detected is not the Attention signal, then the fluid-dispensing device continues its normal operation as represented by terminating symbol **850**.

If, on the other hand, the Attention Signal is received, the fluid dispensing device responds as indicated in independent process symbol **852**. In decision symbol **854** the current state of the water flow is queried. If the water is currently on, the water is turned off as indicated by processing symbol **856,** prior to responding to the request for connected mode.

In independent processing symbol **858**, the command sent by the handheld computer is received. The various commands that can be sent by the handheld computer are described infra and include Scanning **154**, Send Status **156**, Set **158**, End **160**, and Program **152 (FIG. 3**).

A timer starts in processing symbol **860** to return to normal operation after a fixed amount of time. Decision symbol **860** determines whether the End command **160** (as shown in **FIG. 3** and described supra) has been sent. If the End signal is sent, then the fluid-dispensing device returns to normal operation in terminating symbol **876**. If the End command has not been detected, then the process **840** determines in decision symbol **862** whether the entire signal has been sent. If the entire signal has been sent, according

to the bit count expected, then the process determines in decision symbol **866** whether the entire signal was sent. If the command is a valid one, as determined by decision symbol **870**, then the command is decoded and implemented in processing symbol **876**. Connected Mode is then terminated through decision symbol **860** at termination symbol **876**.

FIGS. 5A-5D illustrate the control logic **122** that controls the electronics **114** **(FIG. 1)** of the fluid dispensing device **102**, thereby controlling the communication on the fluid dispensing device node side of the optical link **108**.

With reference to **FIG. 5A**, as indicated by the processing symbol **202**, the fluid dispensing device is powered on or reset. Numerous setup functions are performed in processing steps **214-234 (FIG. 5A)** and **236-238 (FIG. 5B)**. Specific functions related to data communication operations are indicated by processing symbol **230** including initializing the input/output ports, CPU peripheral initialization, and time base module (TBM) process **236** (**FIG. 5B**) initialization. The TBM is responsible for the timing of the IR pulse every 250 milliseconds. It performs the real time interrupt that occurs every 250 milliseconds for cycle timing, and it monitors seconds and hours.

With reference to **FIG. 5B**, a pulse cycle includes generally powering up the microprocessor, attempting the detection of the Attention signal emitted by the handheld computer, emitting a pulse from the fluid dispensing device emitter, and powering down the microprocessor. The processing symbol **240** is the first processing symbol in this process. It indicates that the processing element included in the electronics component **114** (**FIG. 1**) is powered off as a first step in a pulse cycle. The TBM determines that 250 milliseconds have elapsed, and the microprocessor is awakened as indicated by processing symbol **242**. In this processing step, the overall firmware process **202** also waits for the phase-locked loop to lock in order to maintain a constant 4.0 MHz for normal operation.

The processing symbol **244** represents the initiation of the interrupt driven IR and Battery Sampling Routine. The interrupt driven IR and Battery Sampling Routine is now discussed with reference to **FIG. 6A** and **6B**. The Interrupt Driven IR and Battery Sampling Routine begins at input symbol **328** in **FIG. 6A** and is designated general throughout as reference numeral **326**.

The IR and Battery Sampling routine is interrupt driven and is generally responsible for sampling the battery voltage and obtaining a reflected sample of an IR pulse from the emitter **118 (FIG. 1)**. The processing step **330** represents the sampling and saving of a battery voltage reading. The decision step in **332** determines whether the battery voltage is extremely low. If the battery voltage is low, then the IR and Battery Sampling Routine **326** returns to the overall firmware program **202** represented by the output symbol **364** in **FIG. 6B**. If the battery voltage is not low, then the IR receiver is powered on, which is represented by processing symbol **334**. In decision symbol **336**, the optical sensor flag is examined to determine if the detector **116 (FIG. 1)** is connected. If the optical sensor flag indicates that the detector **116 (FIG. 1)** is unplugged, only the loaded battery voltage is sampled. In processing step **338** the MOSFET is turned on, the loaded battery voltage is sampled and the voltage is saved, as represented by processing step **340**. The Analog to Digital Converter (ADC) is then turned off, as represented by processing step **342**. Routine **326** then exits in terminator symbol **364 (FIG. 6B)**.

If the detector is not unplugged, as indicated in decision step **336**, then the Routine **326** waits for the 3 volt power supply to stabilize, as indicated by processing step **344**.

In processing symbol **346** the range on the optical sensor is set to low or high, and the IR transmit regulator is enabled to initiate a pulse. With reference to **FIG. 6B**, once the infrared transmit pulse is enabled, the Routine **326** waits for the pulse time then tests the detector **116** to determine a reflection in processing symbols **348** and **350**, respectively. The IR transmit is then disabled in processing step **352**. Processing step **354** indicates that an additional delay of approximately 7 microseconds is allowed so that an entire reflection sample can be detected. The reflected IR is sampled and saved just before the pulse peak in processing step **356**. Once the reflected pulse is completed, the IR ambient level is sampled and saved in processing step **360**. The IR receiver and the ADC are then turned off. The IR and Battery Sampling Routine **326** then returns to the thread handler in **FIG. 5**.

Processing step **246** represents enabling the switch input thread that is executed every 2 seconds. This thread queries the necessary input mode and makes changes accordingly.

Processing step **248** represents a "kernel" loop that cycles through and calls each of the other active threads. Each thread has separate phases, which are typically run once each thread call, and control movement to the next phase. Thread diagrams show one phase of the same thread run directly after the last. Any other active threads and their current phases would run before the same thread is accessed again.

The next processing symbol **250** represents a thread that is responsible for performing analog conditioning and error checking on values obtained from the battery and the infrared receiver. **FIG. 7** is a flow chart of the Analog Conditioning and Error Checking Thread represented by the processing step **250**. The program starts at input symbol **368** in **FIG. 7A**.

The thread represented by **FIG. 7** has four phases including phase 0, phase 1, phase 2, and phase 3. Phase 0 performs an analysis on the battery voltage level of the system and makes adjustments in the system to compensate for voltage changes. Phase 0

begins in processing step **370** in **FIG. 7A** with a battery sample from the IR and Battery Sampling Routine **326** illustrated in **FIG. 6**. The voltage of the battery is initially sampled at calibration time. The calibration voltage is stored and is used in determining the operating voltage of the system. The calibration voltage is compared to a standard value that is a constant value stored in the system. Standard voltage is a constant expected value of the voltage of the system under normal conditions. The calibration voltage and the standard voltage are compared as indicated by the decision symbol **372**. The current real-time battery voltage is then calculated. If calibration voltage is greater than the standard voltage, then the battery voltage is determined as represented by processing symbol **374**, subtracting from the sample obtained from the IR and Battery Sampling Routine **326** the difference between the calibration voltage and the standard voltage. If the standard voltage is greater than the calibration voltage, then the current real-time battery voltage is determined as represented by processing symbol **376**, adding to the sample voltage the difference between the standard voltage and the calibration voltage. Next, the battery voltage is analyzed as indicated by the decision symbol **380** to determine if the voltage is below an operational level. If the voltage is below operational level and the previous voltage level obtained from a prior sample is less than or equal to a warning level, then the system is entered into emergency shut down mode as indicated by the predefined processing symbol **388**.

With reference to **FIG. 7C**, as indicated by the decision symbol **394**, the current real-time voltage is compared to 5.5 volts. If it is greater than 5.5 volts, then the thread exits and the software is reset, as indicated in symbol **396**. If the previous voltage level is greater than the voltage warning level, then the thread enters Phase 1 in **FIG. 7E**.

If, however, as indicated in the decision symbol **380**, the voltage is not below an operational level, processing symbol **384** (**FIG. 7B**) and processing symbol **398** (**FIG. 7C**) indicate that the IR and Battery Detection Routine adjusts the IR emitter power corresponding to changes in the operating voltage of the system. With reference to **FIG. 7B**, if the voltage has decreased since the last battery voltage sample, then the current real

time battery voltage is saved to a variable, LastV, representing the previous sample voltage value, as indicated by processing symbol **390**.

With reference to **FIG. 7D**, The emission power level of the IR emitter is then adjusted to compensate for the decrease in the overall system power changes. The decision symbol **392** indicates that the range of the optical emitter is examined. If the range of the optical emitter is selected low and the transmit level is at a minimum, then the range of the emitter is set to high and then transmit level is set to a maximum as indicated by processing symbols **406** and **408**, respectively.

When the loaded voltage of the system decreases, more power is provided to the emitter to compensate for the decrease. This allows the emitter to have a more constant range. If the range is not selected as low, as a result of the query indicated by decision symbol **392**, then the decision symbol **410** indicates that the range is analyzed to determine if it is low. If the range is low, but the transmit level is not at a minimum, then the transmit level is altered in processing symbol **412** subtracting from the transmit level a variable integer, Tstep.

This allows decreasing adjustment of the transmit level where the range of the device is already toggled low, yet the power of the system has decreased. Decreasing the transmit level decreases the required power of the emitter. If the query in decision step **410** indicates that the range is not set low, then decision symbol **414** determines if the transmit level is at a minimum high. If it is, then the transmit level is altered in processing symbol **416** by subtracting from the transmit level a variable integer, Tstep.

If the overall system voltage has increased since the last battery voltage sample, then decision symbol **398 (FIG. 7C)** indicates an adjustment for an increase in overall system operating voltage. With reference to **FIG. 7D**, processing symbol **418** examines the current real time operating voltage to determine if the voltage is greater than the last voltage reading. If the current voltage is greater than the last voltage reading, then decision symbol **420** queries the range and the transmit level of the IR emitter. If the

range is selected as high and the transmit level is at a maximum , then the range is set to low in processing symbol **422** and the transmit level is set to low. If the transmit level is not at a maximum, then the transmit level is examined to see if it is less than the maximum transmit level subtracting an integer variable, TStep. If the transmit level is capable of being adjusted from the query in decision step **424**, then the processing step **428 (FIG. 7F)** indicates that the IR transmit level is adjusted, providing the sensor more current. This is accomplished by increasing the transmit level by a variable integer, Tstep.

Once the IR emitter transmit level is adjusted for either an increase or a decrease in overall system power, the IR and Battery Detection Thread **366**, as indicated in **FIG. 7E** examines the overall system voltage reading in decision symbol **400**.

If the voltage level is below the warning level, then a flag is set in processing symbol **402** that indicates that the voltage level is below the warning level. With reference to **FIG. 7F**, if the voltage level is greater than the warning level, then the warning count is set to zero in processing symbol **430**, and the voltage low warning flag is cleared in processing symbol **432**. The unloaded battery voltage is compared to the battery high level in decision symbol **460**. If the voltage is high, an error is indicated in processing symbol **462**. Then the previous voltage variable is set to the correct voltage valve in processing symbol **438.**

With reference to **FIG. 7E**, at processing symbol **404**, if the warning count indicates a 20-second low voltage, then the low battery warning flag is set. In processing symbol **436**, the current real time voltage reading of the overall system is saved to the variable indicating the previous voltage reading to be used by the next iteration of the IR and Battery Detection Thread **366**. Phase one begins at processing symbol **438**.

The starting point for phase one is indicated by processing symbol **438** in **FIG. 7E.** Phase one (1) of the Analog conditioning and Error Checking Thread **366** is responsible for determining if the IR sample received from the IR and Battery Sampling

Routine is within believable limits. In addition, phase one examines the IR electronics to determine if the electronics are in working order.

The IR reflection sample received in the IR and Battery Sampling Routine **326** is saved to a time-sequenced array in processing step **438**. The decision symbol **440** indicates that the array is examined, comparing it to believable values. With reference to **FIG. 7G**, If the values are valid, then an error is not indicated and the IR Sample Lost Error flag is reset in processing symbol **442.** If the values do not appear to be valid, then the Error flag is set in processing symbol **444**.

In processing symbol **446**, a test is performed on the overall system voltage to determine if the collar that contains the electronics **114 (FIG. 1)** is working properly. The decision step **448** indicates that the voltage is examined comparing the normal operating voltage of the overall system to the voltage value at a time when the IR electronics are operating (this value is indicated as loaded voltage). If the loaded voltage is greater than the normal operating voltage, then the difference between the two voltages is examined as indicated by decision symbol **450**. If the difference between the two voltages is greater than or equal to 71 mV, then the comparison indicates that the IR electronics (the collar) are in working order, and the flag indicating an error is cleared in processing symbol **454**. If the difference is less than 71 mV, then the flag is set in processing symbol **456** to indicate an error.

If the symbol **448** indicates that the loaded voltage is less than the normal operating voltage, this indicates that the IR electronics are not working properly. Consequently, the error flag is set in processing step **452**.

Phase two begins at processing symbol **458**. Phase two of the Analog Conditioning and Error Checking Thread **366** examines the IR ambient sample received in the IR and Battery Sampling Routine **326 (FIG. 6)** indicated by processing symbol **360 (FIG. 6B)**. The ambient sample is an IR sample by the detector **116 (FIG. 1)** when the

emitter **118 (FIG. 1)** of the present invention is not active; therefore, the ambient sample is an IR reading that indicates the normal environmental IR present.

With reference to **FIG. 7G**, as indicated by decision symbol **462**, the ambient sample is saved to a time-sequenced array, and the query determines whether the IR ambient sample is within believable limits.

If the IR ambient sample is within valid limits, then an error flag is reset to indicate no error in processing symbol **464**. If the value is not within believable limits, the detection flag is cleared in processing symbol **466** and an error is set that indicates that the IR ambient sample is not valid. The flag indicating that the decision has been made is set in processing symbol **486**. Next, the decision symbol **468** indicates a query to determine if the last pulse cycle resulted in activation of the fluid dispensing device. If the last cycle resulted in the activation of the fluid dispensing device, then the IR dynamic base is set to the sum of the ambient value and the reference base decreased by the "hand block level" as indicated in processing symbol **472**. The "hand block level" is a constant value subtracted in order to account for errors in invalid detection readings.

With reference to **FIG. 7I**, if the difference between the reflection sample and the IR dynamic base is greater than the detection value, the detection flag is then set in processing symbol **490** if the decision symbol **476** inquiry shows that the difference between the reflection sample and the IR dynamic base indicates that an object is detected. Because the IR dynamic base does not include the previously reflected IR from the user's hands, the difference between the IR dynamic base and the reflection sample will indicate detection. If the decision symbol **476** query does not indicate that an object is present, then the detection flag is cleared as indicated by processing symbol **478**. Lastly, the IR decision made flag is set in processing symbol **486**.

If the last cycle did not result in the activation of the fluid dispensing device in decision symbol **468 (FIG. 7G)**, then the IR dynamic base is set equal to the sum of the ambient value and the reference base increased by the "Body Level" as indicated in

processing symbol **474**. The "Body Level" is a constant based on the current range setting of the detector, requiring more energy to turn on the faucet. As indicated by the decision symbol **480**, if the difference between the reflected sample obtained in the IR and Battery Sampling Routine **326** and the dynamic base is greater than or equal to a detection value, then the detection flag is set in processing symbol **484**. Thereafter, the IR decision made flag is set in processing symbol **386**. If, on the other hand, the difference is not greater than or equal to the detection value, then the detection flag is cleared in processing symbol **482**, and the IR decision made flag is set as indicated by processing symbol **486**.

Phase three of the Analog Conditioning and Error Checking **366** releases thread control and resets the phase of the thread to zero. This is indicated in processing step **488**. The thread then returns as indicated by termination symbol **492**.

The overall firmware operation **202** in **FIG. 5** continues at processing symbol **252** in **FIG. 5B**. In processing symbol **252**, the DIP switches of the system are read to ensure proper operation modes.

Processing symbol **254** indicates a call to the Motion Detection Thread **501**, the flowchart for which is illustrated in **FIG. 8A-8D**. The Motion Detection Thread **501** is that functional part of the software that determines if the fluid dispensing device should remain activated in light of motion detected by the emitter/detector pair.

With reference to **FIG. 8A**, the Motion Detection Thread **50** begins at processing symbol **504** at phase one. As indicated by processing symbol **504**, Phase 1 of the Motion Detection Thread **501** is executed when the device is currently dispensing fluid. The decision symbol **506** queries the IR Detection Flag to determine if an object was detected by the IR and Battery Sampling Routine **326.** If the Detection Flag is set, the counter for water flow timeout is set to zero (0) as indicated in processing symbol **500.**

The decision symbol **512** determines whether the water has been running for more than forty-five (45) seconds, which is a timeout limit. If the water has been running more than 45 seconds, then an over limit flag is set indicating that the water running limit is reached, and the flag indicating that the water is running is reset or cleared as indicated by processing symbol **516**. The solenoid is pulsed to close the valve in processing symbol **518**.

If the water has not been running for more than forty-five seconds in processing symbol **512**, then the 45 second timeout is checked in **522**, and the last reflected IR sample is retrieved in **524**. The last reflected sample obtained in the IR and Battery Sampling Routine **326** is then compared to the current IR sample in decision symbol **526**. If the current sample exceeds the previous sample, then the last IR sample is subtracted from the current IR sample. If the difference is less than a predetermined value that indicates motion threshold in decision symbol **542**, then a flag indicating that no motion was detected is incremented as indicated in processing symbol **544**. If the difference is not less that the predetermined value, then a flag indicating that motion was not detected is reset or cleared as indicated in processing symbol **546**.

With reference to **FIG 8B**, if in decision symbol **526** the query indicates that the current sample does not exceed the previous sample, then the current IR sample is subtracted from the last IR sample as indicated by the decision symbol **538**. If the difference is less than a predetermined value that indicates a motion detection threshold, then a flag is incremented as indicated in processing symbol **548 (FIG. 8A)** that indicates that no motion was detected. If the difference is not less that the predetermined value, then the flag indicating no motion detected is cleared as indicated in processing symbol **540 (FIG. 8B)**.

With reference to **FIG. 8C**, decision symbol **550** indicates that, if the flag indicating that no motion is detected exceed the motion timeout value, then the Motion Detection Thread **500** returns as indicated by the terminating symbol **554** in **FIG. 8C**. In other words, no motion is detected, and it has exceeded timeout, then the Motion

Detection Thread **500** terminates until the water is activated again. With respect to **FIG. 8D**, if the timeout duration has not been surpassed, then the Motion Detection Thread **500** proceeds by resetting the flag indicating no motion and the counter in processing symbol **556**. The Water Running indicator is cleared in processing symbol **558**, and a separate process as indicated by the process call **560** is initiated that pulses the solenoid to close the valve.

Phase four begins at processing symbol **562**. If the IR Detection Flag is clear (no detection of a user's hands) by the query indicated in decision symbol **564**, then the thread returns to the water off phase zero (0) as indicated in processing symbol **552 (FIG. 8C)**.

With reference to **FIG. 8D**, if a user's hands are detected in the decision symbol **564**, then the previous reflected IR sample is retrieved in processing symbol **566**. The current reflected IR sample is compared to the previous reflected IR sample in decision symbol **568**. If the current sample is greater than the previous sample in decision symbol **568**, then the difference in the current IR sample and the previous IR sample is examined to determine if it exceeds the IR motion change threshold in decision symbol **570**. If it does not meet or exceed the threshold, then the thread returns in the terminator symbol **554 (FIG. 8E)**. In other words, a drop in IR will not turn on the water. If it does indicate a motion change in decision symbol **570**, then water off phase zero (0) is initiated in processing symbol **572**.

If at the decision symbol **506** in **FIG. 8A,** it is determined that the IR Detection Flag is not set, then there has been no motion detected and the fluid is currently being dispensed from the device. With respect to **FIG. 8B**, if the duration of the fluid dispensing has exceeded a timeout threshold from the query in decision symbol **528**, then the No Motion Detection flag is incremented in processing symbol **530** and the Water Running flag is cleared in processing step **532**. The solenoid is then pulsed to close the valve in the predefined process as indicated in **534**, and the Water Off phase is set to zero (0) in process symbol **536**.

Thread control is then returned to the overall firmware structure **202** as illustrated in **FIG. 5**. In **FIG. 5C**, decision symbol **258** indicates that the firmware determines if there are any pending events. If there are pending events then the main thread timer is queried to determine if a cycle has expired. If the cycle time has expired, the cycle begins again at processing step **240 (FIG. 5B)** where the microcontroller is deactivated until the next cycle is initiated on the 250 millisecond interval.

If the cycle time has not expired, then the optical sensor looks for the Attention signal initiated by the handheld computer in processing symbol **262**. The Attention signal is emitted by the handheld computer as indicated in the Send Status function **178** in processing step **182 (FIG. 4)**. If the handheld computer has requested connected mode of the fluid dispensing device and the Attention signal is a valid signal, then the decision symbol **264** indicates that a transmit status response is sent to the handheld computer in the subsequent predefined process step **266**. Once the Status Response is transmitted, then the handheld computer and the fluid dispensing device enter connected mode as indicated in predefined processing symbol **268**. The firmware remains in connected mode until a command is transmitted or a timeout occurs in processing symbol **268**. If an End command is communicated by the handheld computer or a timeout occurs, the variables for the thread events are reset and the DIP switches are queried as indicated in processing symbol **270**.

The TBM interrupts are re-enabled in processing symbol **272** allowing the pulse cycle to continue, then the operation of the IR electronics are examined as indicated in the decision symbol **274**. If the IR electronics have been unplugged then the system is configured to do reflection calibration in one (1) second in processing step **276**. In decision symbol **278**, the IR electronics are then tested to determine if the devices are unplugged, if there is a battery warning, or if there exist any other errors. If each of the queries returns a negative response, then this error data is saved in processing symbol **282**.

The error indications are saved into a report for user accessibility in processing symbol **284**. The decision symbol **288** queries the error bits to determine if the errors changed from the last iteration of the firmware structure **202**. If the error has changed, then the previous error is saved in processing symbol **290**. With reference to **FIG. 5D**, the TBM interrupts are re-enabled in processing symbol **292**, and error messages are transmitted to the handheld computer in predefined process symbol **294**.

The decision symbol **296** indicates a query of the IR electronics. If the electronics are working properly, then the pulse cycle is reinitiated in **FIG. 5B** at processing symbol **240**.

If the electronics are not working properly, then the system is placed into low power IR electronics unplugged Mode in predefined processing symbol **300**. The system remains in low power mode as indicated by the decision symbol **302** until the electronics are reactivated. Once the IR electronics begin working properly, processing step **308** indicates that the preparation is taken for the recycling of the IR and Battery Sampling. Thread control is reset in processing symbol **310**. If the calibration flag is set, then the TBM Interrupt Service Routine is initiated in processing symbol **314**. If Factory calibration is required as determined in decision step **316**, then the predefined Factory Calibration Thread is run as indicated by the predefined Factory Calibration symbol **318**. The system then holds until reset in process symbol **320** at which time the Firmware structure begins anew at decision symbol **208** in **FIG. 5A**.

If Factory Calibration is not indicated in the decision symbol **316**, then the predefined Dynamic Calibration is run as indicated in the predefined processing symbol **322**. To reinitiate the threads, the TBM interrupts are reset in processing symbol **324**, and a pulse cycle begins at processing symbol **240** where the microcontroller is deactivated until a cycle is initiated by the TBM.

If Factory Calibration is not indicated, then the Dynamic Calibration Thread **598** as illustrated in **FIG. 9** is run from the firmware overview structure **202** at processing

symbol **322**. The Dynamic Calibration Thread **598** is executed both initially when the firmware is first powered up and periodically to adjust the IR hardware components as required by environment and system changes.

The Dynamic Calibration Thread **598** starts at the input symbol **600** in **FIG. 9A**. The calibration begins by initializing required variables, setting the initial emitter selection to low, and setting the IR LED current to a nominal value (the transmit level) as indicated in processing symbol **602**. The microcontroller is deactivated for the duration of a regular 250 milliseconds TBM cycle in processing step **604**. The Interrupt Driven IR and Battery Sampling Routine **326 (FIG. 6)** is called in order to obtain initial samples of the battery voltage as indicated in processing step **330 (FIG. 6A)**, the reflected IR as indicated in processing step **356 (FIG. 6B)**, and the ambient IR as indicated in processing step **360 (FIG. 6B)**.

Processing symbol **608** indicates that the Dynamic Calibration Thread **598** sets the current input to the IR LED based on the battery voltage sample obtained from the IR and Battery Sampling Routine **326 (FIG. 6)**. The current range is set to high if the compensated battery voltage is less than the switchover point in processing symbol **610**, and processing symbol adjusts the IR LED current if it exceeds an operational limit that affects performance.

Decision symbol **614** begins the actual calibration of the IR LED and the optical sensor. If the transmit level (or initially the nominal IR LED current) is less than a minimum transmit value in order for the IR emitter to reach an effective range, then the microcontroller is deactivated until the next TBM cycle in processing symbol **616 (FIG. 9B)**, and the Interrupt Driven IR and Battery Sampling Routine **326 (FIG. 6)** is run in processing symbol **618** in **FIG. 9D**.

With reference to **FIG 9D**, in the decision symbol **620**, the reflected IR including the ambient sample is compared to the ambient level when the IR LED has not emitted a

pulse. This is in contrast to the initial setting that simply used reference values according to the standard LED based on the battery voltage reading.

With reference to **FIG. 9C**, if the sum of the reflected IR and the ambient level is greater than the ambient level when the IR LED has not emitter a pulse, then the reflected IR is the Reference Base Value as indicated in processing symbol **622**. If the IR level, which is defined as the sum of the Reference Base, the Reflected IR, and the Ambient IR, is below a detectable saturation limit in decision symbol **624**, then the current input to the IR LED is examined in decision symbol **626**.

If the current input to the IR LED is below the low limit, then the transmit level is set to a maximum value in processing step **634**, and an error bit is set that indicates that the emitter cannot be adjusted down any farther in processing symbol **636**. The battery voltage is then equalized in processing symbol **630** in order to prevent battery error, and the Dynamic Calibration Thread returns as indicated by the terminator symbol **646**, with errors. If the current input to the IR LED is not below the low limit, then the battery voltage is then equalized in processing symbol **630** in order to prevent battery error, and the thread returns as indicated by the terminator symbol **646**, without errors.

If the sum of the reflected IR and the ambient level is not greater than the ambient level when the IR LED has not emitted a pulse in decision symbol **620 (FIG. 9D)**, then the difference between the Ambient IR and the Reflected IR (including the Ambient IR) is examined in decision symbol **638** in **FIG. 9D**. If the difference is less than the expected noise level, then the Reference Base is set to zero (0). If the difference is not less than the expected noise level, then an error bit is set in processing symbol **642**, and the IR level is examined in decision symbol **624**. If it is below a detectable limit, then the process provides an error before exiting if the IR LED current was below a low limit. If it was not below a low limit, it simply exits.

COMMUNICATION PROTOCOL

Data communication between the optical interface ports of the handheld computer **104 (FIG. 1)** and the fluid dispensing device **106 (FIG. 1)** is now described. Communication between the devices is implemented as Broadcast Mode or Connected Mode.

Broadcast Mode

The Broadcast mode is employed when the receiving control logic of a preferred embodiment discovers errors including, but not limited to, a malfunctioning solenoid, a low battery, or a reflected signal that is out of range at calibration. When such an error is detected during the normal operations of the firmware of the fluid dispensing device, a signal is emitted from an IR emitter **118 (FIG. 1)** of the fluid dispensing device.

The signal emitted has the following format:

ERRSSSSSSSE(CS)(LF).

The emission is sent once per second. The specification of the signal is illustrated in **FIG. 10**. The first three bytes indicate that the signal is a Broadcast signal including an ASCII "ERR" **650**. The next byte **656** includes an 8-bit serial number identifying the unit that has detected an error. Byte **658** indicates the type of error that has been detected. The following table describes the types of errors and the corresponding byte indicators:

BIT	ERROR TYPE
Bit 0	Solenoid Open Circuit or Unplugged
Bit 2	Solenoid load too heavy
Bit 3	Ambient IR level out of Range
Bit 4	Reflected IR out of

	range at Calibration
Bit 5	Low Battery Warning
Bit 6	Collar Unplugged

TABLE 1

The checksum byte **660** is a modulo 256 checksum inverted, and the last byte is an ASCII linefeed **662** to indicate termination of the signal.

The control logic of the handheld computer processes a discovered error(s) and communicates the error(s) to the handheld computer. The Broadcast Communication Process is shown in **FIG. 22** and is designated generally throughout with reference numeral **882**.

Decision symbol **884** determines if an error has been detected within the fluid-dispensing device. Within the system, a timer is set, for example to broadcast error messages every five (5) pulse cycles. Therefore, in decision symbol **886** it is determined whether it is time to send out a Broadcast Signal. If it is not, then the fluid dispensing device continues with normal operation in terminating symbol **892**.

If it is time to transmit a Broadcast Signal, then the error data is sent in processing symbol **888**.

The handheld computer executes a scanning function that can be initiated by a user. **FIG. 3** represents the communication function of the handheld computer. The optical interface port is initialized **148**, and the IR-State variable is set indicating that the port is open in **150**. The gCommand variable of the switch symbol **152** indicates that a user has selected the scan functionality. The scan function searches for a Broadcast signal of the type described.

Once detected, the signal is parsed and the information is stored on the handheld computer. This information is then readily available to the user for maintenance purposes.

Connected Mode

The Connected Mode is initiated by the handheld computer when a user selects a functionality that requires data to be sent to the fluid dispensing device. As described, infra, an Attention Signal is emitted from the optical interface port of the handheld computer.

The Attention Signal specification is illustrated in **FIG. 11**. The Attention Signal is defined as a hexadecimal "FF" **664**. The "FF" is followed by a four (4) byte computer software identification ASCII code **668**. The four-byte code **668** includes 4 ASCII characters identifying the company and product. The last byte **670** indicates an Original Equipment Manufacturing (OEM) code.

The "FF" **664** is sent continuously for 300 milliseconds (approximately 50 milliseconds longer than a normal fluid dispensing device pulse cycle). This allows the fluid dispensing device the opportunity to detect the Attention Signal if the Attention Signal is initially sent during a 250 millisecond cycle.

The fluid dispensing device responds within 39 milliseconds (14 milliseconds if the water is off). If there is no response from the fluid dispensing device, then the Attention Signal is sent repeatedly at a predetermined interval until a response is detected by the handheld device.

The Attention Signal response sent by the fluid dispensing device includes status information that is described with reference to **FIG. 12**. The initial ASCII "STA" byte **672** indicates that the fluid dispensing device is responding to the Attention Signal. The 8-byte serial number **674** indicates the serial number of the device responding to the

Attention Signal. This 8-byte word is displayed on the handheld computer as a hexadecimal number. The 2-byte software version **676** indicates to the handheld device the version of the firmware used on the fluid dispensing device. The next 2-byte PCB version **678** indicates the board revision number and the part number of the board. The one-byte Engineering Change Order ("ECO") level indicates previous maintenance order. The one-byte IR input level **681** identifies the IR sensitivity. The one-byte IR reference base reading provides an eight-bit reading. The one-byte IR ambient reading **683** is provided. The one-byte IR battery voltages **684** and **686** provide a normal operating battery voltage and a battery voltage at the end of a solenoid pulse, respectively. The following two bytes provide an hour count **688** for time purposes. The IR transmit calibration level byte **690** provides a voltage output value of the emitter, and the next byte provides a one-byte voltage level **692** of the voltage being used. The next byte is the battery calibration level **694** indicating a voltage reading of the battery at calibration. A one-byte solenoid count **696** and a two-byte solenoid 10's count **698** follow. The dip switch settings are indicated in the next byte **670**. The following table describes the bit numbers with corresponding definitions:

BIT	DESCRIPTION
B7	DIP Switch 5 (water saver)
B6	DIP Switch 1 (Range 1)
B5	DIP Switch 2 (Range 2)
B4	DIP Switch 3 (Scrub Mode, 60 second off delay)
B3	DIP Switch 4 (Meter Mode)
B2	Unused extra input jumper
B1	Not used
B0	Not used

TABLE 2

The virtual DIP switch settings are provided in byte **672** and are defined the same as the manual DIP switch settings except B0 is defined as "Use All Virtual Settings." Range offset **674**, delay in seconds **676**, past error bits **678**, and current error bits **680** provide additional information describing the current fluid dispensing device parameters. Status of the fluid dispensing device is given in the next byte **682** and the bits are defined as follows:

BIT	DEFINITION
B4	PROGRAMMING ERROR, NUMBER OF BYTES SPECIFIED
B2	PROGRAMMING ERROR, ADDRESS SPECIFIED
B1	FLASH PROGRAM OPERATION NOT VERIFIED
B0	LAST COMMAND CHECKSUM FAILED

TABLE 3

A one-byte spare is provided **684**, and the transmission is terminated with a checksum **686**, and a linefeed **688**.

Once connected mode is established, the handheld computer has several functions. The handheld computer can send a status request, send a set command, or send a program command.

A status request from the handheld computer is responded to by the fluid dispensing device indicating that information that is sent when Connected Mode is accomplished. The status request flowchart in **FIG. 4** illustrates the software flow on the handheld computer when a Status command is requested. Processing symbol **184** indicates the transmission of a Status command, and the specification for the Status command is illustrated in **FIG. 13**. A status command begins with and ASCII "SST"

690. A one-byte spare **692** is followed by a checksum **694** and an ASCII linefeed **696** for termination.

A Set command allows a user of the handheld device to reprogram various electronics of the fluid dispensing device, including but not limited to the DIP switches (i.e. virtual DIP switch settings), range offset, delay in seconds, sound, hardware settings, and connected mode timeout. **FIG. 14** illustrates a string transmitted by the handheld computer to accomplish a Set command. The ASCII "SET" string **700** is sent in the least significant byte. Following the "SET" string is an eight-byte serial number **702** indicating the handheld computer that is initiating the "SET" command. The one-byte virtual DIP switch settings **704** are described by the following table:

BIT	DESCRIPTION
B7	DIP Switch 5 (water saver)
B6	DIP Switch 1 (Range 1)
B5	DIP Switch 2 (Range 2)
B4	DIP Switch 3 (Scrub Mode, 60 second off delay)
B3	DIP Switch 4 (Meter Mode)
B2	Unused extra input jumper
B1	Not used
B0	All Virtual Settings

TABLE 4

The emitter range offset is provided in the next byte **704**, and a delay is provided in the next byte **708**. The sound can be turned on/off with the sound byte **710**. B0 indicates sound off. Byte **712** provides the IR ambient level reading. The user can reset hardware settings in the following byte **714** including B0 that resets the main board and B1 that indicates a soft reset. Resetting the main board includes the fluid dispensing device waiting 10 seconds, exiting Connected Mode, then resetting all the variables. A Soft Reset includes waiting 10 seconds, exiting Connected Mode, retaining virtual settings,

and re-calibration. The next byte **716** allows the Connected Mode timeout to be changed in the range of 0-255 seconds. Finally, a spare byte **718**, a checksum byte **720** and an ASCII linefeed **722** terminates the "SET" command.

A Program Command allows a handheld computer user to reprogram the fluid dispensing device. The Program Command Specification is illustrated in **FIG. 15.** ASCII "PRG" **724** initiates a Program Command. A four-byte serial number **726** follows indicating the identification of the handheld computer. The next two bytes **728** provide the target address of the fluid dispensing device. Typically, the target address includes the software type, the PCB code and the address returned from an "STA" Command. The number of bytes making up the new code is transmitted in one byte **730**, and the code itself is transmitted in the following 128 bytes **732**. If the code exceeds the 128 byte limit, then multiple "PRG" Commands can be sent from the handheld computer in order to transmit the entire piece of code. A checksum **734** and an ASCII linefeed **736** terminate the signal.

The handheld computer sends an End Command as illustrated in **FIG. 16** in order to terminate the Connected Mode between the handheld computer and the fluid dispensing device. An ASCII "END" string **738** initiates the End Command. It is followed by a one-byte spare **740** and a checksum **742**. The End Command is terminated by an ASCII linefeed **744**.

GRAPHICAL USER INTERFACE OF HANDHELD COMPUTER

The graphical user interface (GUI) of the handheld computer is now described with reference to **FIG. 17**. The handheld computer **750** generally includes a casing **756** having a monitor **754**, an optical interface port **752**, and a power button **756**. The monitor can be a touch-screen or any other type of monitor known in the art.

The system provides the user with several options including 1) "Get Faucet Data" **758**, 2) "Adjust Faucet" **760**, 3) "Scan for Problems" **761**, 4) "Information" **762**, 5)

"Troubleshoot" **764**, and 6) "Help" **766**. Of the six (6) options provided, options 1) through 3) require communication with the fluid dispensing device.

The "Get Faucet Data" option **758** retrieves and stores fluid dispensing device information. Retrieval of the fluid dispensing device data is accomplished by executing the SST command of the handheld computer. As described, the handheld computer emits an Attention Signal. When the fluid dispensing device detects the Attention Signal the handheld computer and the fluid dispensing device enter Connected Mode. The fluid dispensing device then transmits a set of information describing various parameters of the fluid dispensing device.

Once the data is retrieved, the data is stored in the handheld computer for user accessibility. **FIG. 18** illustrates the GUI interface that is displayed once the data is received from the fluid dispensing device. The fluid dispensing device data can be reviewed by pressing the five tabs on the screen including Power **775**, Settings **776**, Usage **778**, Time **780**, and Miscellaneous **782**.

The Power tab **775** contains data relating to the power operating parameters of the fluid dispensing device. These parameters include normal operating voltage, loaded voltage, time in use and battery replacement date.

The Settings tab **776** contains data on the various system settings accessible to the user. These settings include, but are not limited to, operating mode, range setting, range offset, delay setting and virtual settings. The factory default operating mode is the normal motion detecting mode where water flows within 250 milliseconds after activating sensor and stays on as long as motion is detected. The maximum on time in this mode is 45 seconds. Additional modes include scrub mode where water continues to flow for sixty (60) seconds after deactivation of the sensor, metered mode having a 10-second flow time from first hand detection, and water saver mode having a 5-second maximum on time starting from first hand detection and fast turnoff when hands are removed.

The Usage tab **778** provides information such as the number of uses, uses per day and uses per month. The Time tab includes the time of the scan, the date of the scan and the total on-time for the faucet. Finally, the Miscellaneous tab **782** includes current errors, past errors, software version, PCB number and engineering change level.

Additional pushbuttons Help **784**, Review Data **786**, Next **788**, and OK **790** provide additional functionality. Review Data **186**, when selected, displays data from the fluid dispensing device. Next **780**, when selected, performs another "Get Faucet Data" function on a fluid dispensing device.

The "Adjust Faucet" option **760 (FIG. 17)** allows a user to edit the parameters of the fluid dispensing device and download parameter changes to the device, itself. Selecting the "Adjust Faucet" option **760** from the Commander menu in **FIG. 17** displays the GUI illustrated in **FIG. 19**. This GUI is a form having numerous areas in which the user can enter information about the parameters of the fluid dispensing device. The user can modify the "Range" **792** of the emitter by selecting one of the checkboxes "Short" **810**, "Normal" **814**, "Far" **812** or "Maximum" **816**.

The user can also modify the "Mode" **794** in which the fluid dispensing device is operating. The user can place the device in "Normal" mode **802**, "Scrub" mode **806**, "Metered" mode **804** or "Water Saver" mode **808** by selecting the corresponding checkbox.

The range slider **818** allows the user to add or subtract 2 inches from the optics range. Initially, the user must calibrate the faucet to determine the current range length. The slider can then be used to adjust the current range ±2 inches.

In addition, the user can change the "Delay Time" **796** of the operating mode selected. The user can enter a delay time ranging from zero to 180 seconds by entering

the time in the text field **792**. Also, the user can elect to "Turn off Beeps" by selecting the checkbox **798** or "Reset Faucet" by selecting the checkbox **800**.

Once edits have been completed, the user selects the "SET" pushbutton **820**. As described, infra, with reference to **FIG. 14**, the Set Command is initiated by transmitting the "SET" signal after obtaining Connected Mode. The "SET" stream is sent to the fluid dispensing device, and the requested changes to the device parameters are updated.

The "Scan For Problems" option **761** (**FIG. 17**) allows a user to scan a set of fluid dispensing device, searching for a signal from a device that has entered Broadcast Mode. This allows the handheld device to determine from the Broadcast Mode signal devices that are currently in need of service. Selecting the "Scan For Problems" option **761** from the Commander menu in **FIG. 17** displays the GUI illustrated in **FIG. 20**. As indicated, when the GUI illustrated in **FIG. 20** is displayed, the "Scanning in Progress" message **822** is displayed.

If a fluid dispensing device is in Broadcast Mode, the "Serial Number" **824** of the malfunctioning device is displayed. In addition, errors associated with the device "Error 1" **826**, "Error 2" **828** and "Error 3" **830** are displayed. The user can prevent the handheld device from sounding an alarm by selecting the "Turn Palm Alarm Off" checkbox **832**. Also, the user can select to keep the handheld computer on for as long as you are actively scanning by selecting the "Keep Palm From Turning Off" checkbox **834**.

The user can continue scanning by selecting the "Continue" pushbutton **836**.

While the invention has been described in detail, it is to be expressly understood that it will be apparent to persons skilled in the relevant art that the invention may be modified without departing from the spirit of the invention. Various changes of form, design or arrangement may be made to the invention without departing from the spirit and scope of the invention. For example, the invention as described is not dependent upon specific hardware configurations, nor is it pivotal to employ a specific programming

language to implement the invention as described. Therefore, the above mentioned description is to be considered exemplary, rather than limiting, and the true scope of the invention is that defined in the following claims